Sustainability, Reliability, and Cost: Finding the Balance in Mission Critical Facilities

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www.eypmcf.com

Firm Background

William J. Kosik, PE, CEM, LEED®

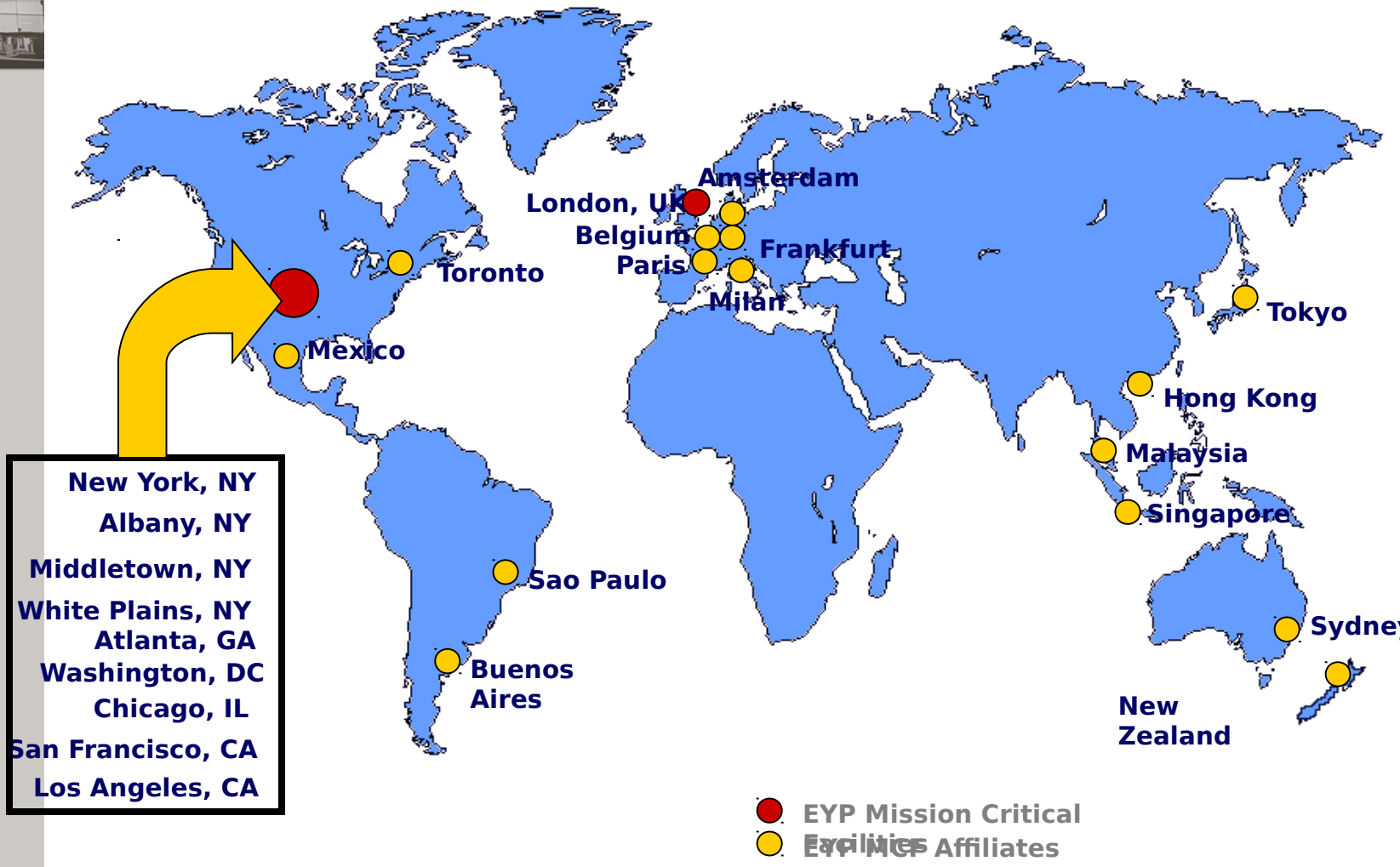
- Chicago Managing Principal, EYP MCF
- Member IDPH IDR Committee
- Consultant to Mayor's Office/DOE on Chicago Standard
- Author: ASHRAE Journal, *Design Strategies for Hybrid Ventilation*, October 2001
- Speaker: World Building Forum, UK; USGBC National Summit Meetings; Healthy Buildings 2000, Helsinki
- Specialist in building performance simulation tools

Firm Background

EYP Mission Critical Engineering

- 250-person international M/E engineering firm
- 30-person Chicago office
- 10 offices including Chicago, NYC, LA, SF, DC, London and Atlanta
- Ranked in top 10 engineering firms by Engineering News Record (ENR) specializing in the design of high technology facilities
- Specializing in analysis, design and commissioning of high-performance buildings
- Corporate, institutional and government project portfolio

EYP MCF Offices and Affiliates



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Market Focus

- Financial
- Federal & State Government
- Technology
- Telecom
- Insurance
- Broadcast / Media
- Healthcare
- Higher Education
- Research

Representative Clients

Government

- FAA - Federal Aviation Administration
- State of Pennsylvania - Dept of General Services
- NASA - Marshall Space Flight Center
- TSA - Transportation Security Administration
- NOAA - National Oceanic and Atmospheric Administration
- NMCI - Navy Marine Corps Intranet
- LOC – Library of Congress
- U.S. Senate & House of Representatives
- DOD - Department of Defense (Pentagon)
- OBO - Dept. of State Overseas Building Operations
- AOC - Arch of the Capitol
- DEA - Drug Enforcement Agency
- Air Force (Goodfellow AFB)
- NYS Office for Technology
- Los Angeles County Data Center
- Lawrence Berkeley National Laboratory

Federal Aviation Administration

Design of Standardized Electrical Power Systems.
Project Scope Includes 35 Major Metropolitan Airports

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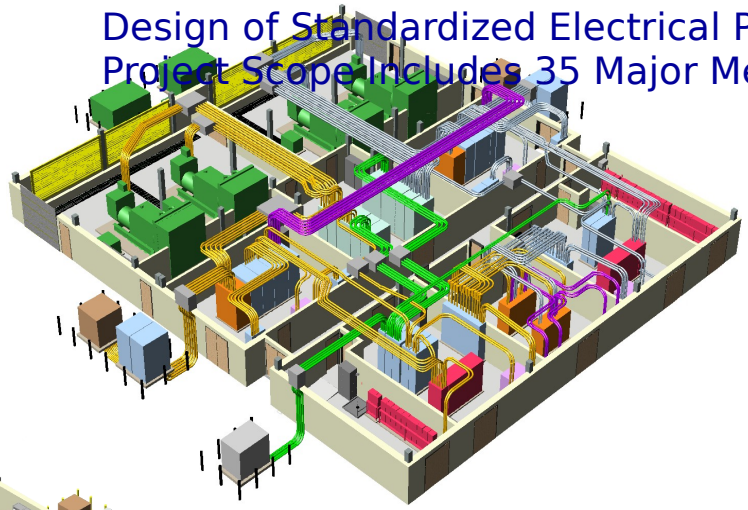
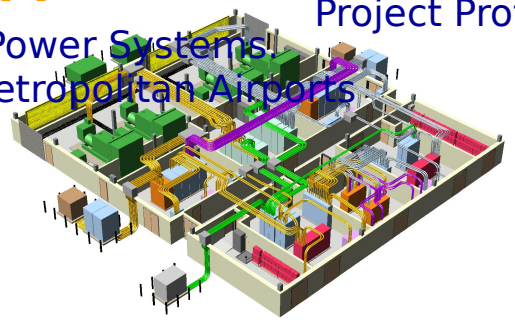
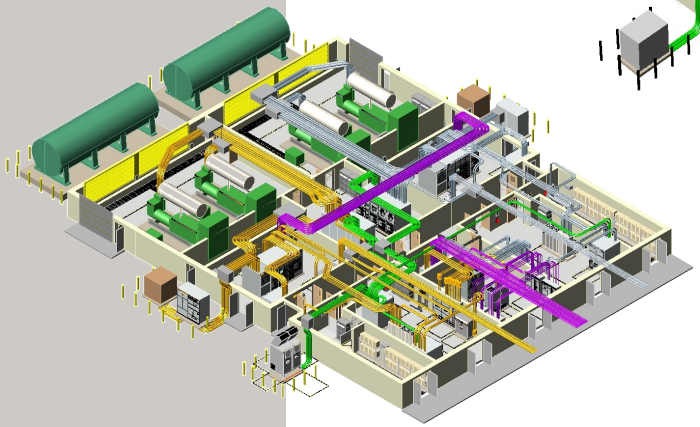
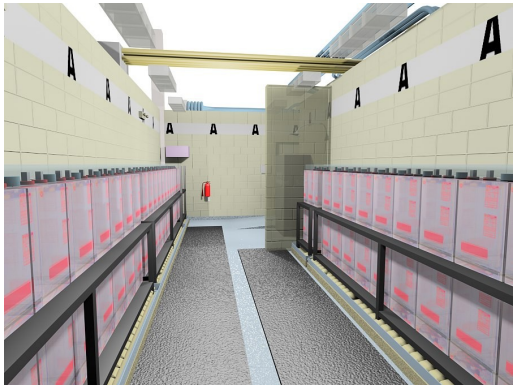
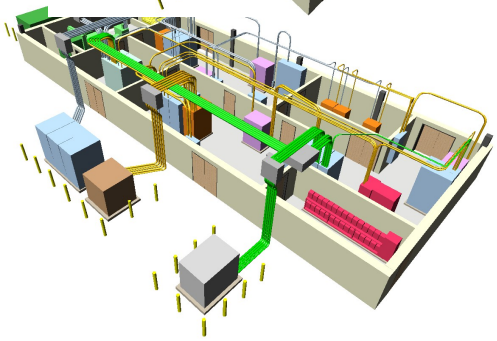
Project Prototypes











Battery Room Detail

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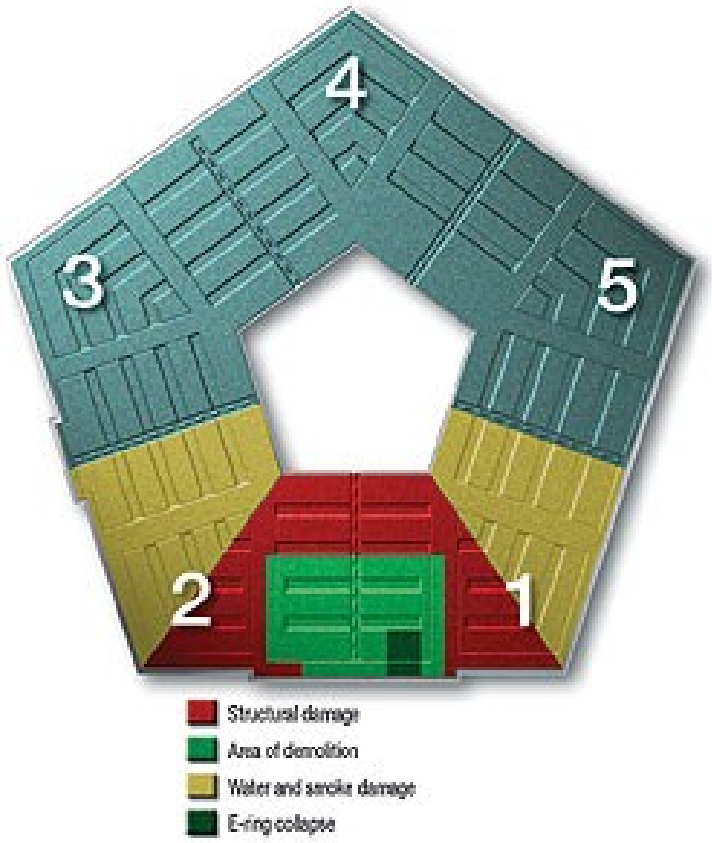
Department of Defense

Various Renovation Projects for the Pentagon



National Oceanic & Atmospheric Administration (NOAA)

218,000 s.f (40,000 s.f Raised Floor)

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Department of State

Embassy/Consulates: Rome, London, Prague, Buenos Aires, Istanbul

Fannie Mae

Data Center/Office (250,000 s.f.)

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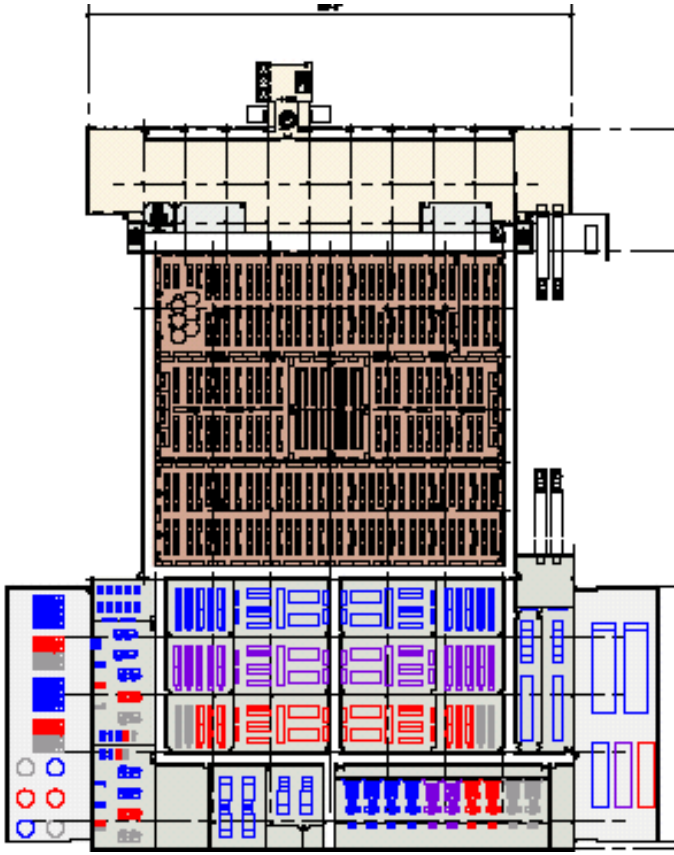
Fannie Mae

130,000 SF data center

70,000 SF back of house

60,000 SF raised floor

120,000 SF office building



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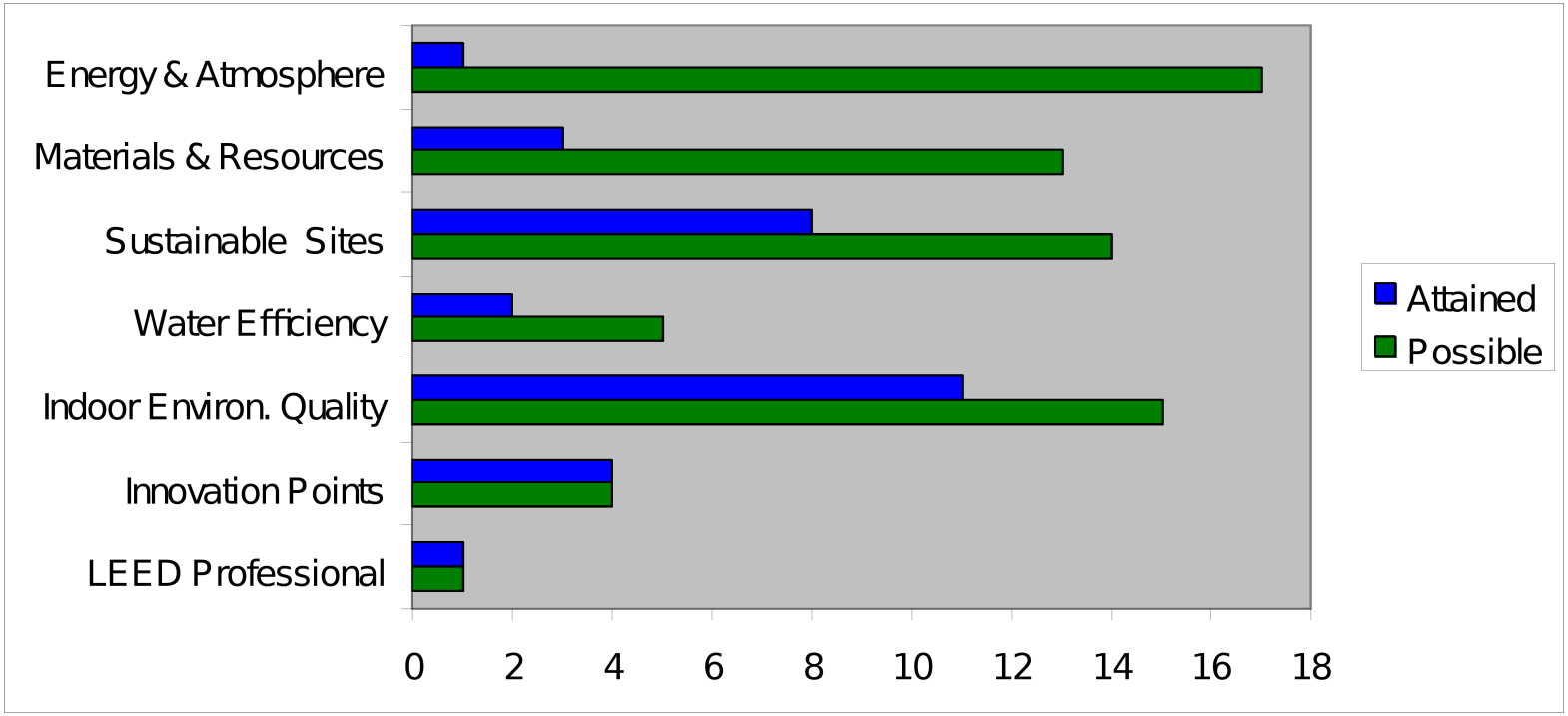
Fannie Mae



28 points total (certified)

Purpose of Presentation

To understand:

- Basics on sustainable design and energy efficiency
- Fundamentals and tools for building performance simulation
- How to use building performance simulation as an integrated part of the design process
- Commissioning and maintenance as a tool
- How reliability and energy efficiency can coexist

Why is This Important?

- Worldwide, buildings consume approximately 40% of all energy produced
- Environmental impact
- Technology building can consume up to 10x the energy over a standard building
- Ongoing operations and maintenance costs
- Security and reliability of critical facilities

Reliability in Mission Critical Facilities

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NAVFAC
Naval Facilities Engineering Command

Operational Continuity and Sustainable Development

RADM Mike Loose, CEC, USN
Commander
Naval Facilities Engineering Command

April 26, 2005

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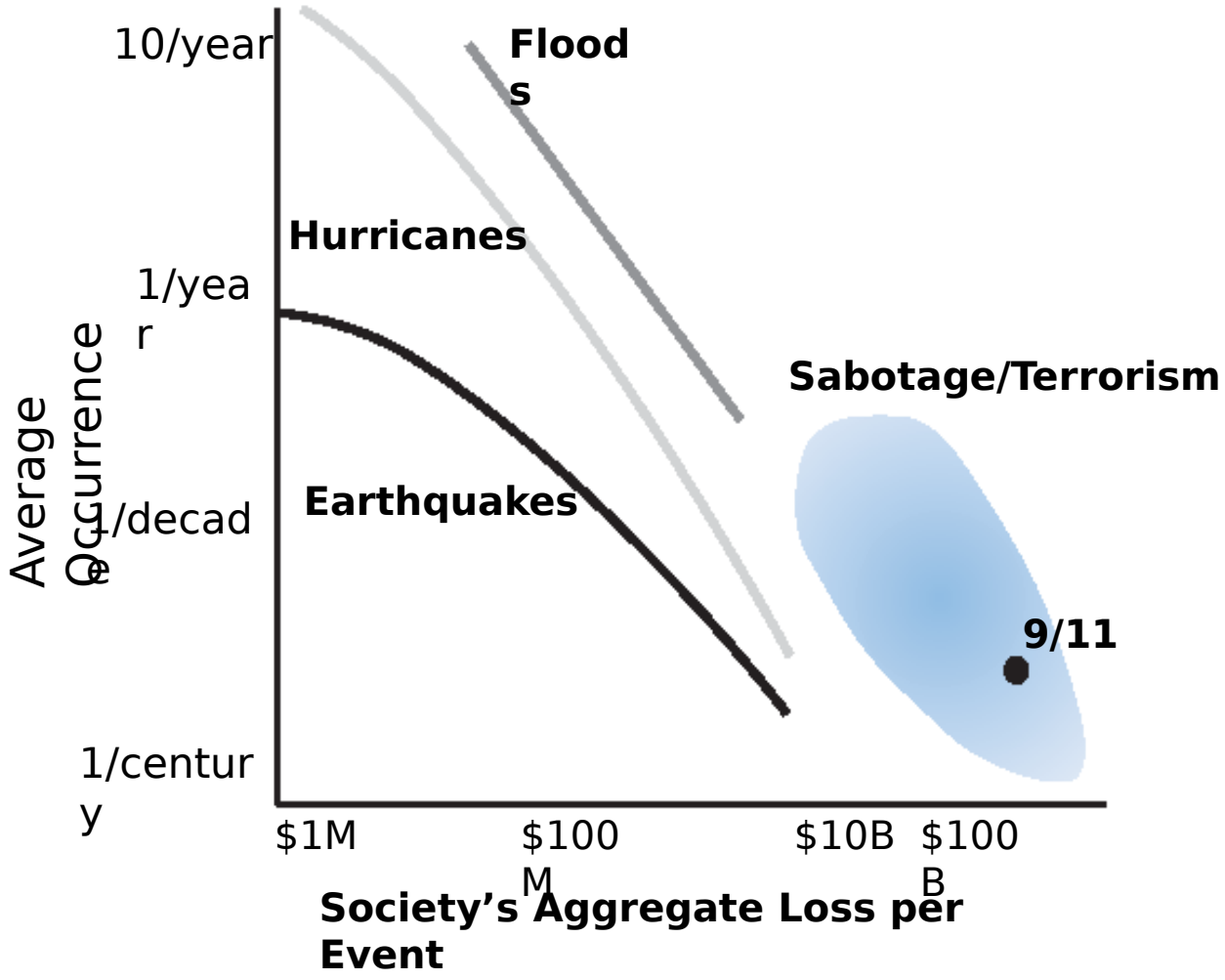
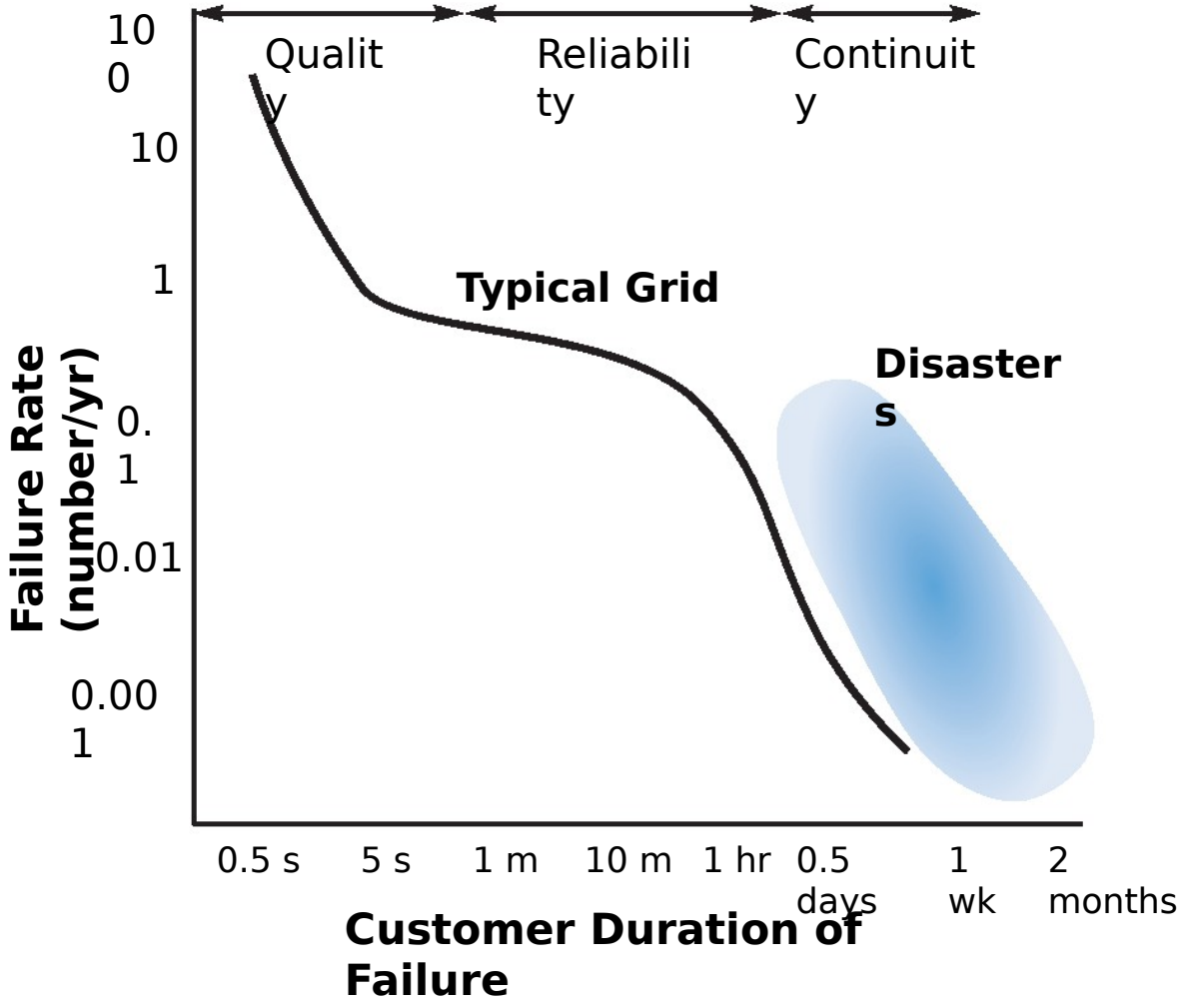
Summary

- Quickly implementing our 25-year vision
- Continuous focus on life cycle cost, energy efficiency, and ATFP
- Strongly soliciting your ideas on how to become more cost effective in Sustainable Development and ATFP

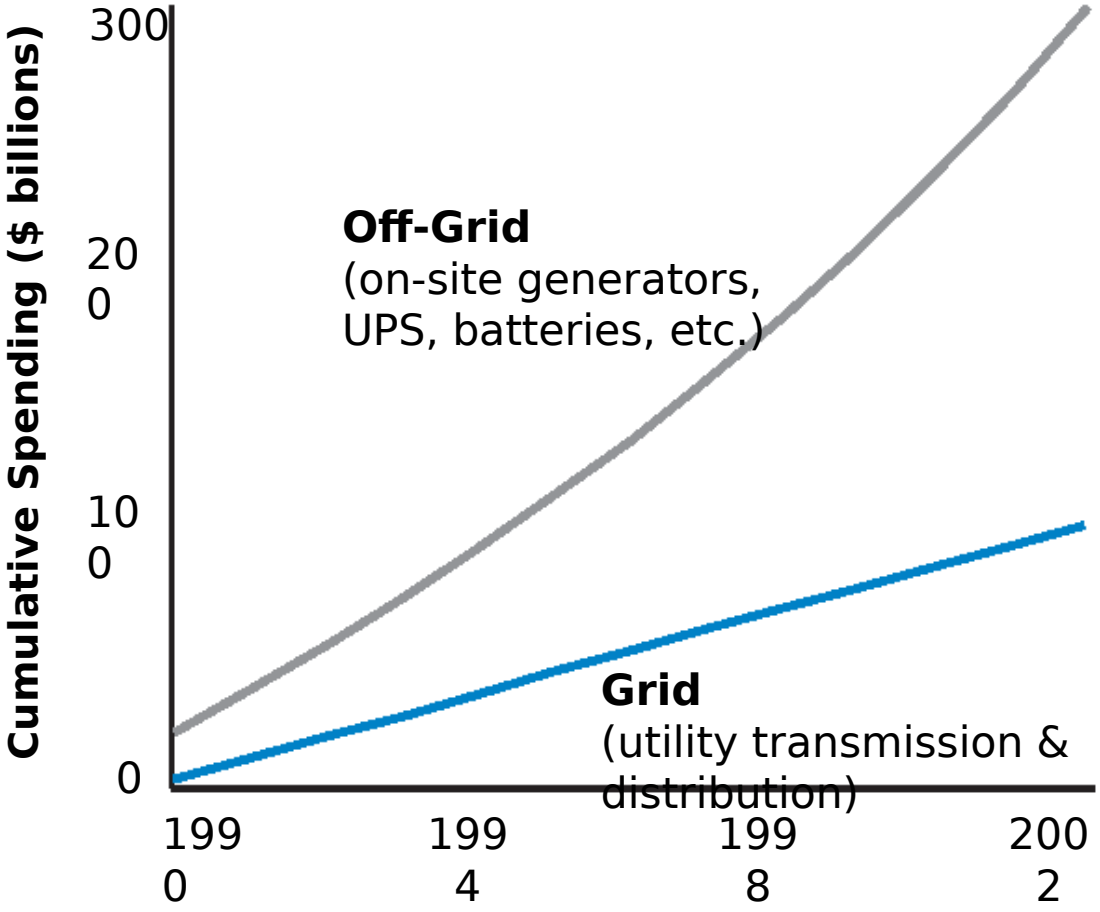
Wide-Impact Disasters



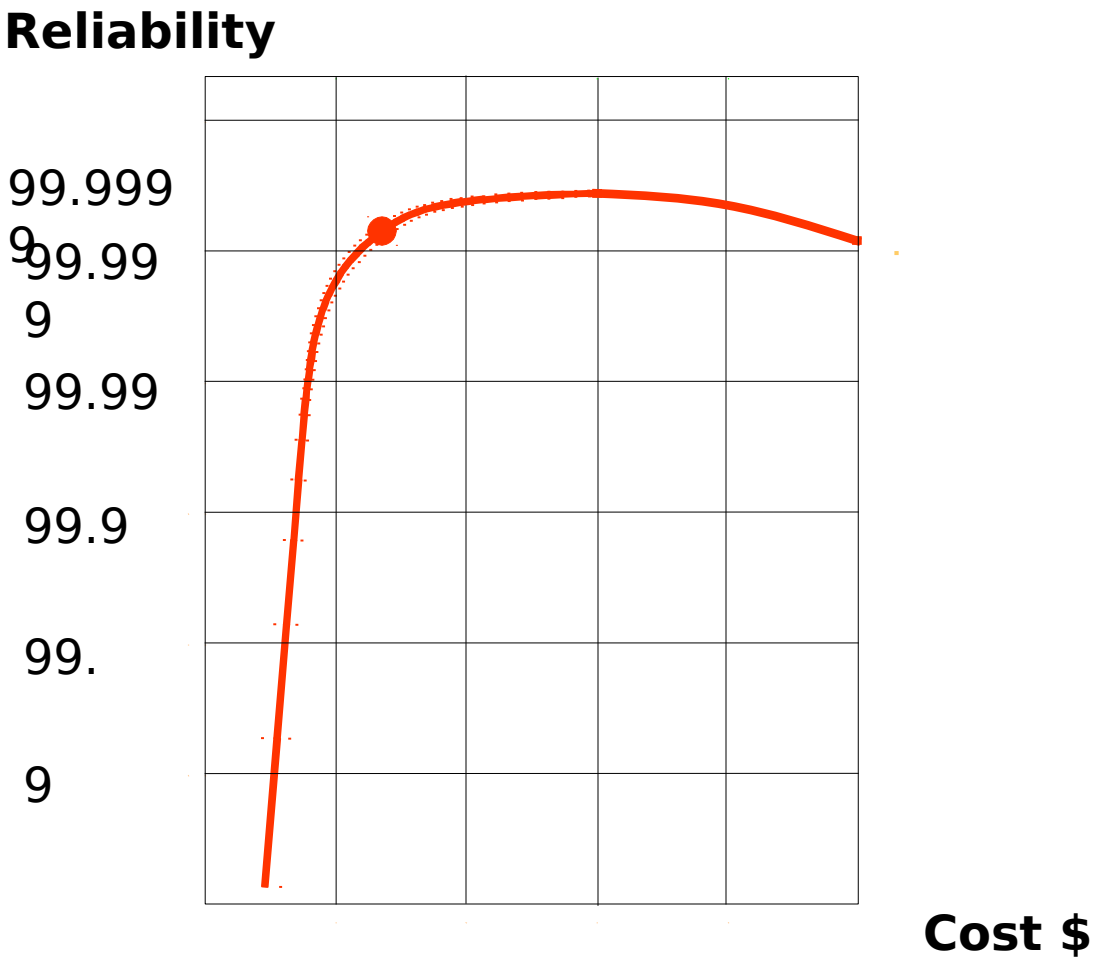
Electric Grid Failures: Customer Perspective



Investing in Power Reliability & Security



The Cost of Reliability



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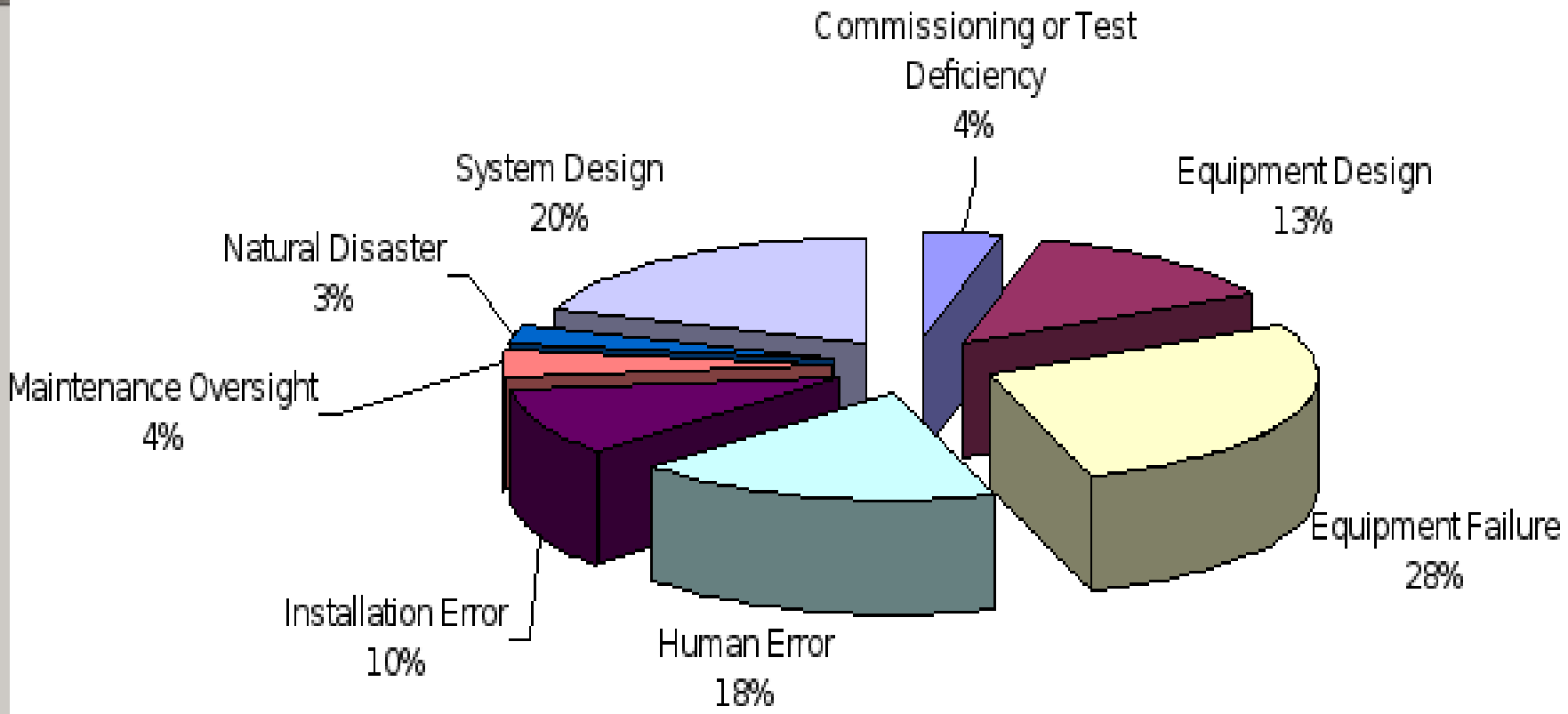
Causes of Critical Failures



Causes of Critical Failures

- Most major failures occur during change of state events
  - Loss of utilities
  - System transfers during maintenance activities
- More maintenance does not necessarily mean higher availability

Energy and Environmental Design

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Status of intelligent buildings in the U.S.

- Movement towards integrated systems
- Continued emphasis on energy and “green”
- Government mandated “green” standards
- Continued advancement of control technologies
- Still first-cost and “value-engineering” pressure

Status of intelligent buildings in the U.S.

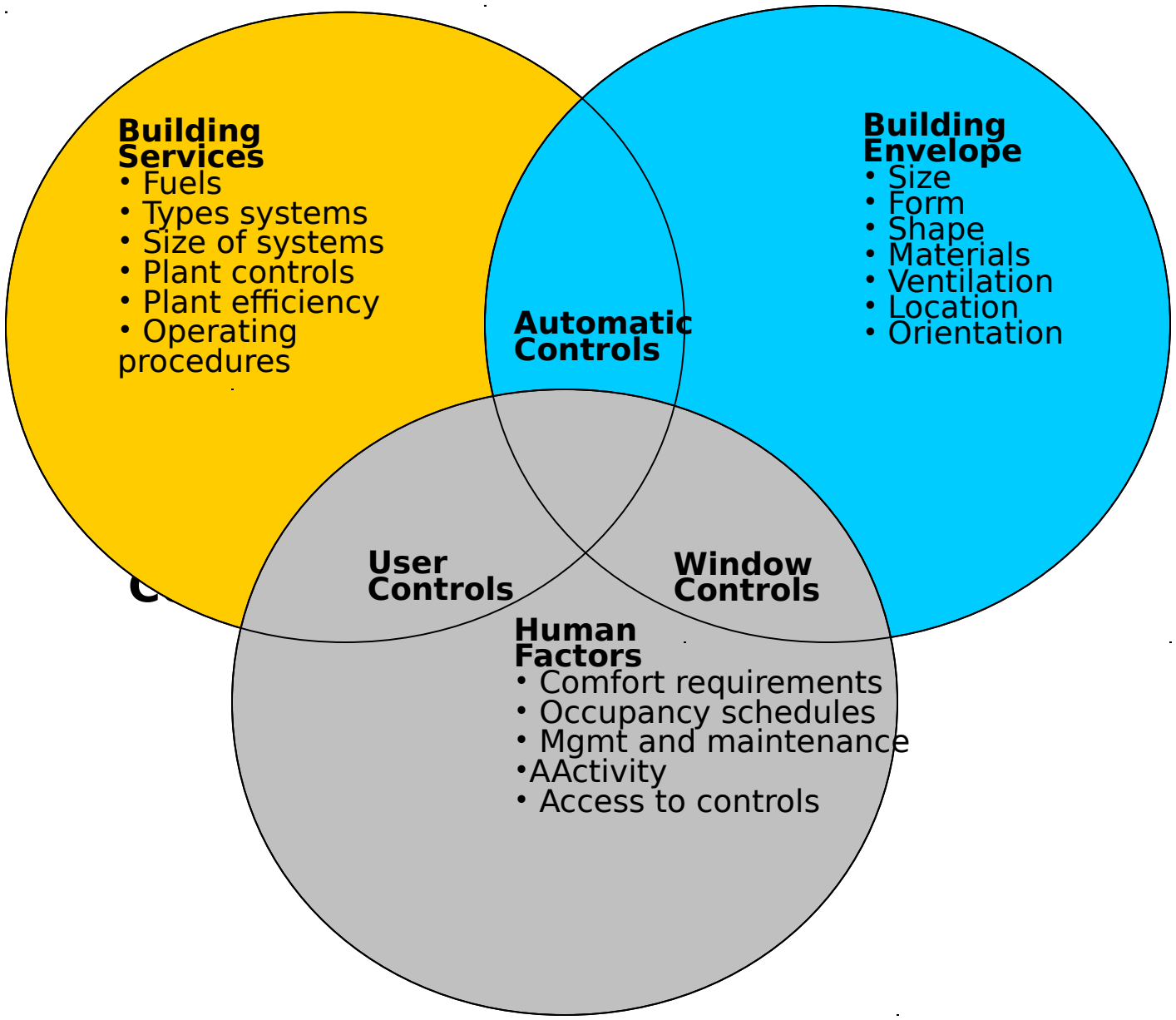
- LEED™ rating system
- GSA's Greening Federal Facilities
- GSA's Facility Standards
- U.S. Environmental Protection Agency (EPA) Energy Star Rating
- High emphasis on energy optimization through building controls
- Other national, state and local energy initiatives

LEED™ Rating System

- Used for commercial and high-rise residential new construction and major renovation
- Evaluates and recognizes performance in accepted green design categories
- Whole-building approach with a collaborative, integrated design and construction process
- Optimizes environmental and economic factors
- Several categories reference building intelligence

LEED™ Rating System

- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Innovation & Design Process



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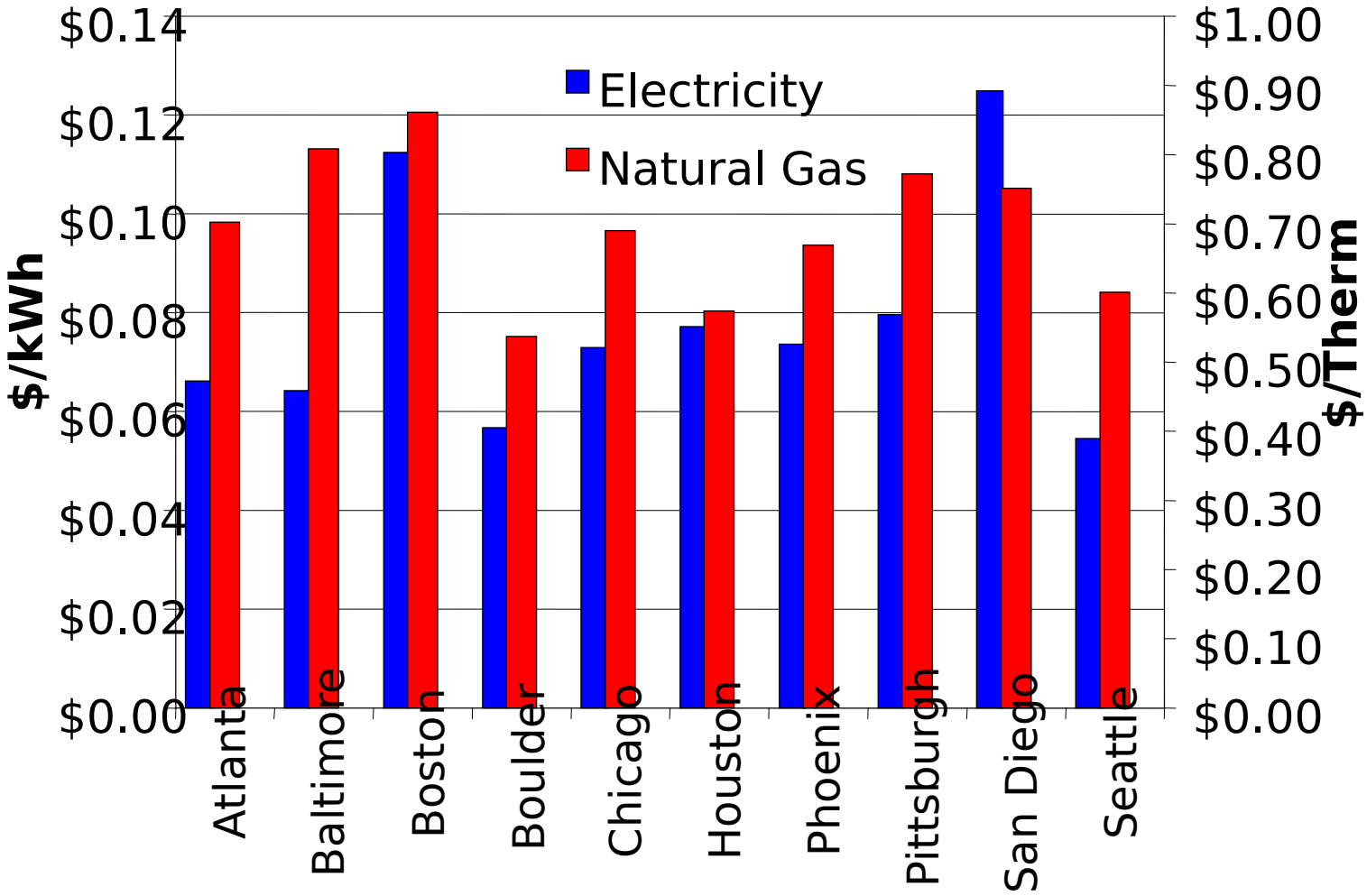
Whole building analysis

- Integration of systems and architecture
- Glazing types
- Shading (overhangs and louvers)
- Thermal mass
- Lighting, including use of daylight
- Building services
- Control strategies
- Operations

Utility Cost Considerations

Utility Costs vs. Location



Utility Costs vs. Location

- Usage cost and demand will vary by location
- Rates can vary as much as 100%
- Understand local utility rate structure before making system selection

Building Performance Simulation

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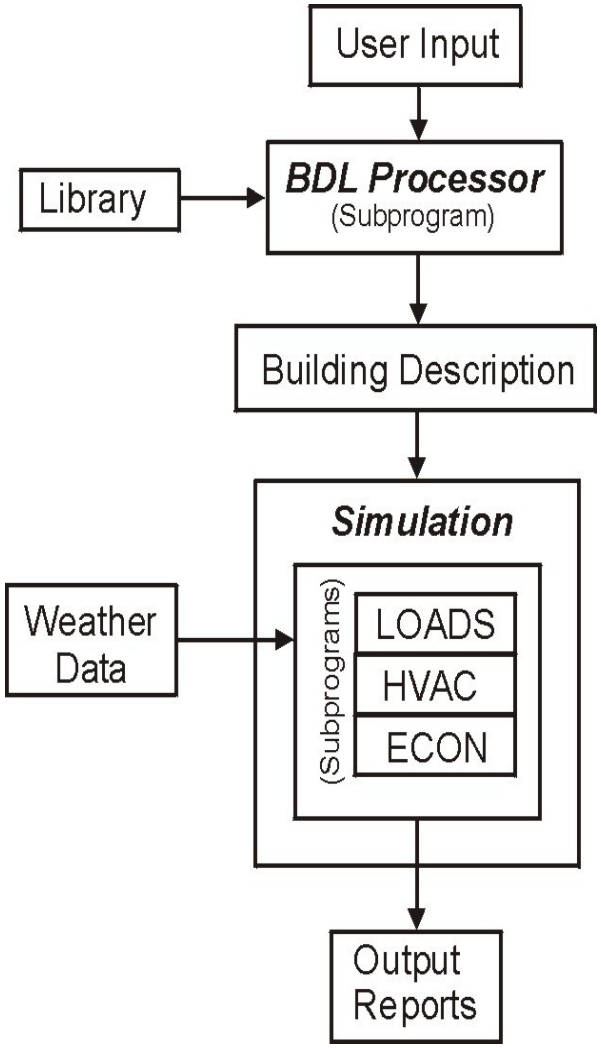
Building Performance Simulation

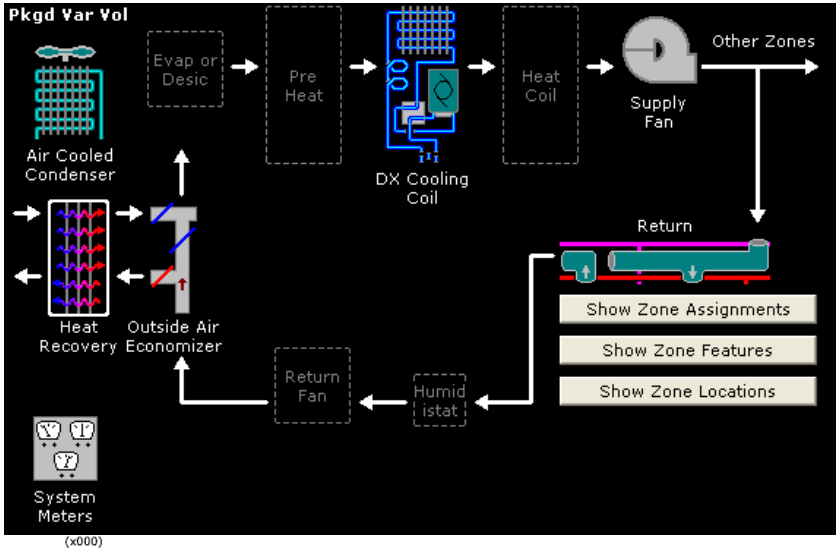
- Energy Analysis
- Computational Fluid Dynamics
- Reliability Modeling
- Integrated Use of Tools

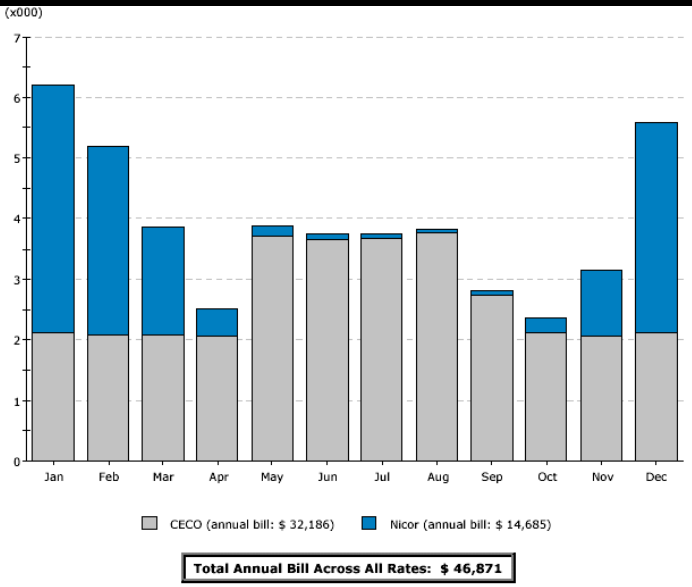
Energy Analysis

- Overview
  - A dynamic simulation (time is the independent variable) of energy flows throughout a building, including the building envelope, room air, and HVAC systems, and the interaction between these.
- Input
  - Weather data, building geometry, construction material information, occupancy, HVAC system, lighting, equipment
- Output
  - Space and surface temperatures, humidity levels, HVAC parameters (flow rates, temperatures, etc.)
  - Component, system, and whole-building energy consumption

DOE2.2 Hourly Energy Simulation







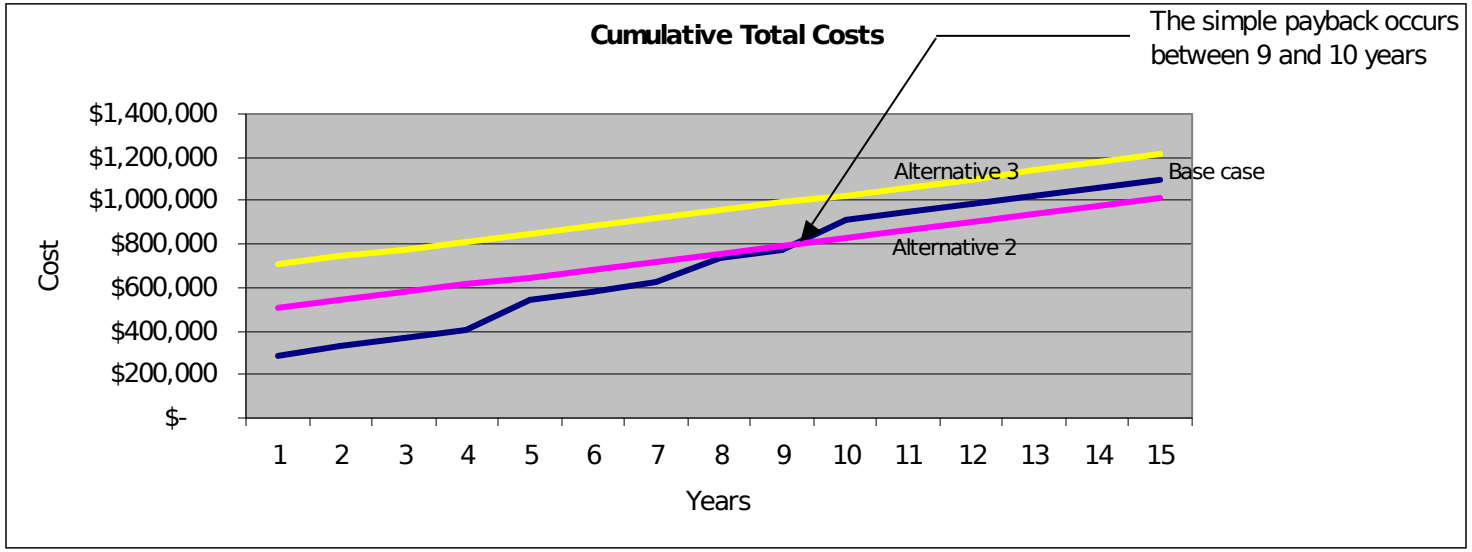
Reduction in Central Plant Size

Scheme	Cooling Plant Size Reduction	Air System Size Reduction
A	Base	Base
B	2%	3%
C	2%	2%
D	9%	16%
E	15%	25%
F	17%	27%

In addition to energy savings, there will be a first cost savings on the central plant systems

Life Cycle Cost Analysis

Year	Alternative 1 - Base Case				Alternative 2				Alternative 3			
	Capital[1]	Maintenance[2]	Energy[3]	Running Total	Capital	Maintenance[2]	Energy[3]	Running Total	Capital	Maintenance[2]	Energy[3]	Running Total
1	$ 250,000	$ 9,000	$ 30,151	$ 289,151	$ 475,000	$ 6,000	$ 28,200	$ 509,200	$ 675,000	$ 8,000	$ 26,000	$ 709,000
2		$ 9,270	$ 30,151	$ 328,572		$ 6,180	$ 28,200	$ 543,580		$ 8,240	$ 26,000	$ 743,240
3		$ 9,548	$ 30,151	$ 368,271		$ 6,365	$ 28,200	$ 578,145		$ 8,487	$ 26,000	$ 777,727
4		$ 9,835	$ 30,151	$ 408,257		$ 6,556	$ 28,200	$ 612,902		$ 8,742	$ 26,000	$ 812,469
5	$ 100,000	$ 8,000	$ 30,151	$ 546,408		$ 6,753	$ 28,200	$ 647,855		$ 9,004	$ 26,000	$ 847,473
6		$ 8,240	$ 30,151	$ 584,799		$ 6,956	$ 28,200	$ 683,010		$ 9,274	$ 26,000	$ 882,747
7		$ 8,487	$ 30,151	$ 623,437		$ 7,164	$ 28,200	$ 718,375		$ 9,552	$ 26,000	$ 918,300
8	$ 75,000	$ 7,000	$ 30,151	$ 735,588		$ 7,379	$ 28,200	$ 753,954		$ 9,839	$ 26,000	$ 954,139
9		$ 7,210	$ 30,151	$ 772,949		$ 7,601	$ 28,200	$ 789,755		$ 10,134	$ 26,000	$ 990,273
10	$ 100,000	$ 6,000	$ 30,151	$ 909,100		$ 7,829	$ 28,200	$ 825,783		$ 10,438	$ 26,000	$ 1,026,711
11		$ 6,180	$ 30,151	$ 945,431		$ 8,063	$ 28,200	$ 862,047		$ 10,751	$ 26,000	$ 1,063,462
12		$ 6,365	$ 30,151	$ 981,947		$ 8,305	$ 28,200	$ 898,552		$ 11,074	$ 26,000	$ 1,100,536
13		$ 6,556	$ 30,151	$ 1,018,655		$ 8,555	$ 28,200	$ 935,307		$ 11,406	$ 26,000	$ 1,137,942
14		$ 6,753	$ 30,151	$ 1,055,559		$ 8,811	$ 28,200	$ 972,318		$ 11,748	$ 26,000	$ 1,175,691
15		$ 6,956	$ 30,151	$ 1,092,665		$ 9,076	$ 28,200	$ 1,009,593		$ 12,101	$ 26,000	$ 1,213,791
	$ 525,000	**$ 115,400**	**$ 452,265**	**$1,092,665**	**$475,000**	**$ 111,593**	**$ 423,000**	**$ 1,009,593**	**$ 675,000**	**$ 148,791**	**$390,000**	**$ 1,213,791**



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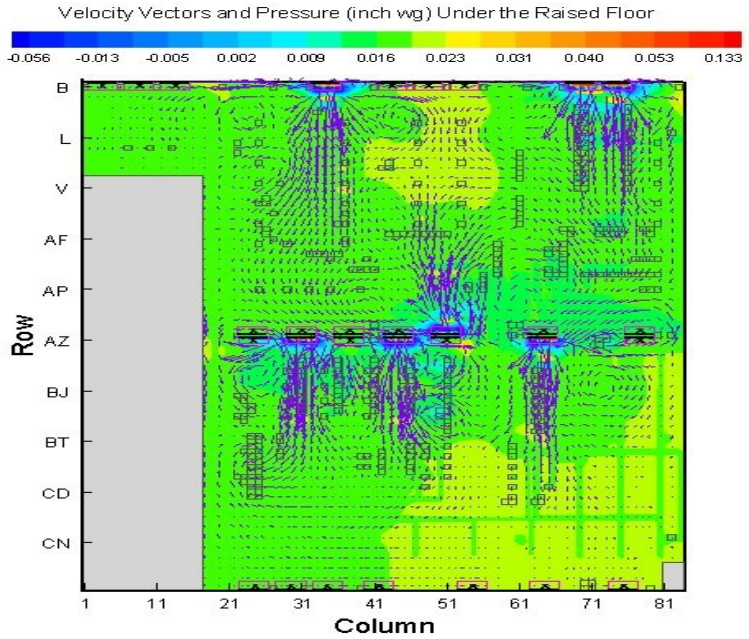
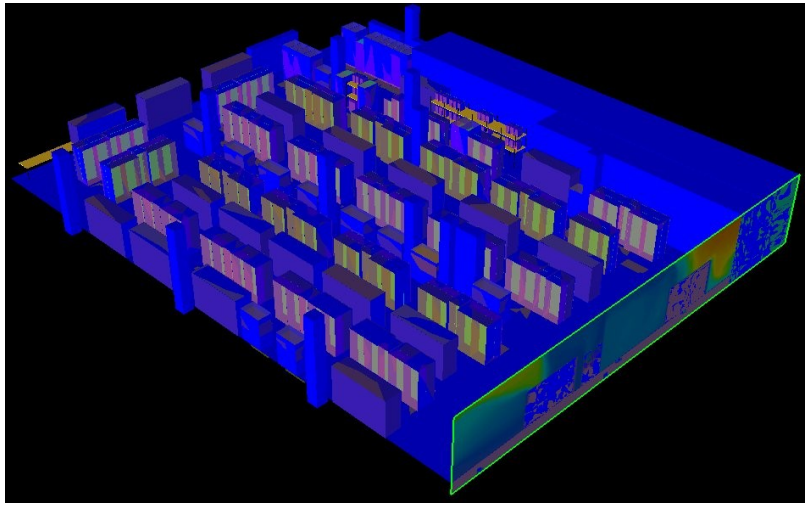
Computational Fluid Dynamics

"...simulates the entire field of airflow throughout a space, including air speed, direction, and temperature."





Reliability Modeling

Office Microsoft

Relex - [UTL 2 MS 2 Gen and 2 UPS SD Dual Cord.RPJ]

File Edit View Insert Format Tools Project RBD Diagram Window Help

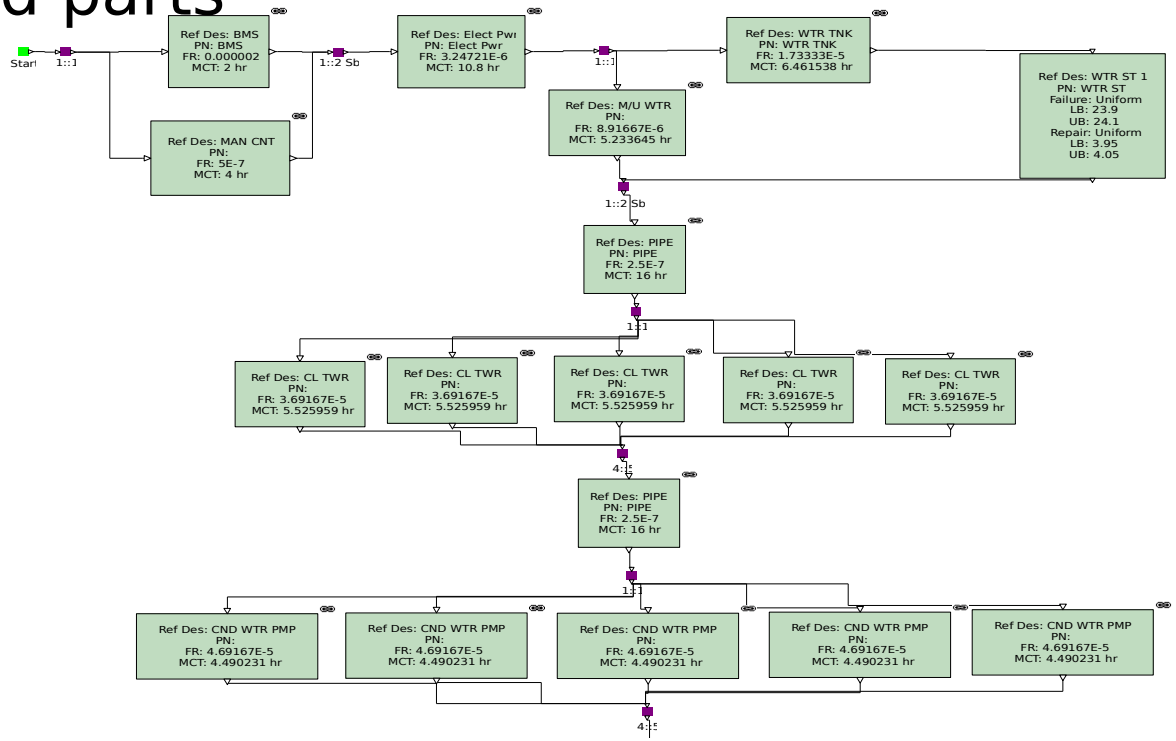
System Tree

Name	Part Num...	Reference...	Description	Failure Rate				
System	System		Top-level a...	0.005660				
Utility Power	Utility	UTL	Utility Power	2.50100E-4				
UTL	Utility	Generic	Utility		4000.000000	2.00	0.000250	User Defined
CTERM2	Cable Ter...	Medium V...	601-15,00...		9970090.0...	11.10	1.00300E-7	User Defined
Transformer	XFMR	XFMR	2000 KVA...	7.22214E-7				
XFMR1	Transformer	Oil Filled			1413000.0...	300.00	7.07714E-7	User Defined
CTERM1	Cable Ter...	Low Voltage	0-600 V		6.89655E+7	4.00	1.45000E-8	User Defined
Main Switchgear	MS	MS	MDP Swit...	1.61605E-6				
CB2	Circuit Bre...	Bolted-in	Bolted-in, ...		912409.00...	8.00	1.09600E-6	User Defined
SB1	Switchboard	Bare	Bare, 0-60...		1.09230E+7	27.00	9.15499E-8	User Defined
CB1	Circuit Bre...	Bolted-in	Bolted-in, ...		2503130.0...	1.00	3.99500E-7	User Defined
CTERM1	Cable Ter...	Low Voltage	0-600 V		6.89655E+7	4.00	1.45000E-8	User Defined
CTERM1	Cable Ter...	Low Voltage	0-600 V		6.89655E+7	4.00	1.45000E-8	User Defined
Automatic Transfer ...	ATS	ATS	Automatic...	3.34783E-6				
ATS	ATS	Generic	ATS		300000.00...	4.00	3.33333E-6	User Defined
CTERM1	Cable Ter...	Low Voltage	0-600 V		6.89655E+7	4.00	1.45000E-8	User Defined
Switchboard	SWBD	SWBD	Switchboard	9.05050E-7				
SB1	Switchboard	Bare	Bare, 0-60...		1.09230E+7	27.00	9.15499E-8	User Defined
CB1	Circuit Bre...	Bolted-in	Bolted-in, ...		2503130.0...	1.00	3.99500E-7	User Defined
CB1	Circuit Bre...	Bolted-in	Bolted-in, ...		2503130.0...	1.00	3.99500E-7	User Defined
CTERM1	Cable Ter...	Low Voltage	0-600 V		6.89655E+7	4.00	1.45000E-8	User Defined
UPS Inverter	UPS INVR	UPS INVR	UPS Inverter	2.04140E-5				
CTERM1	Cable Ter...	Low Voltage	0-600 V		6.89655E+7	4.00	1.45000E-8	User Defined
INVR	UPS	Inverter	Interter in ...		50000.000...	12.00	0.000020	User Defined
CB1	Circuit Bre...	Bolted-in	Bolted-in, ...		2503130.0...	1.00	3.99500E-7	User Defined
UPS Rectifier	UPS RECT	UPS RECT	UPS Recti...	1.70807E-5				

System / RBD Table /

Reliability Modeling

- Develop “system tree”
- Consists of assemblies, sub-assemblies and parts



Combining Reliability and Energy Efficiency

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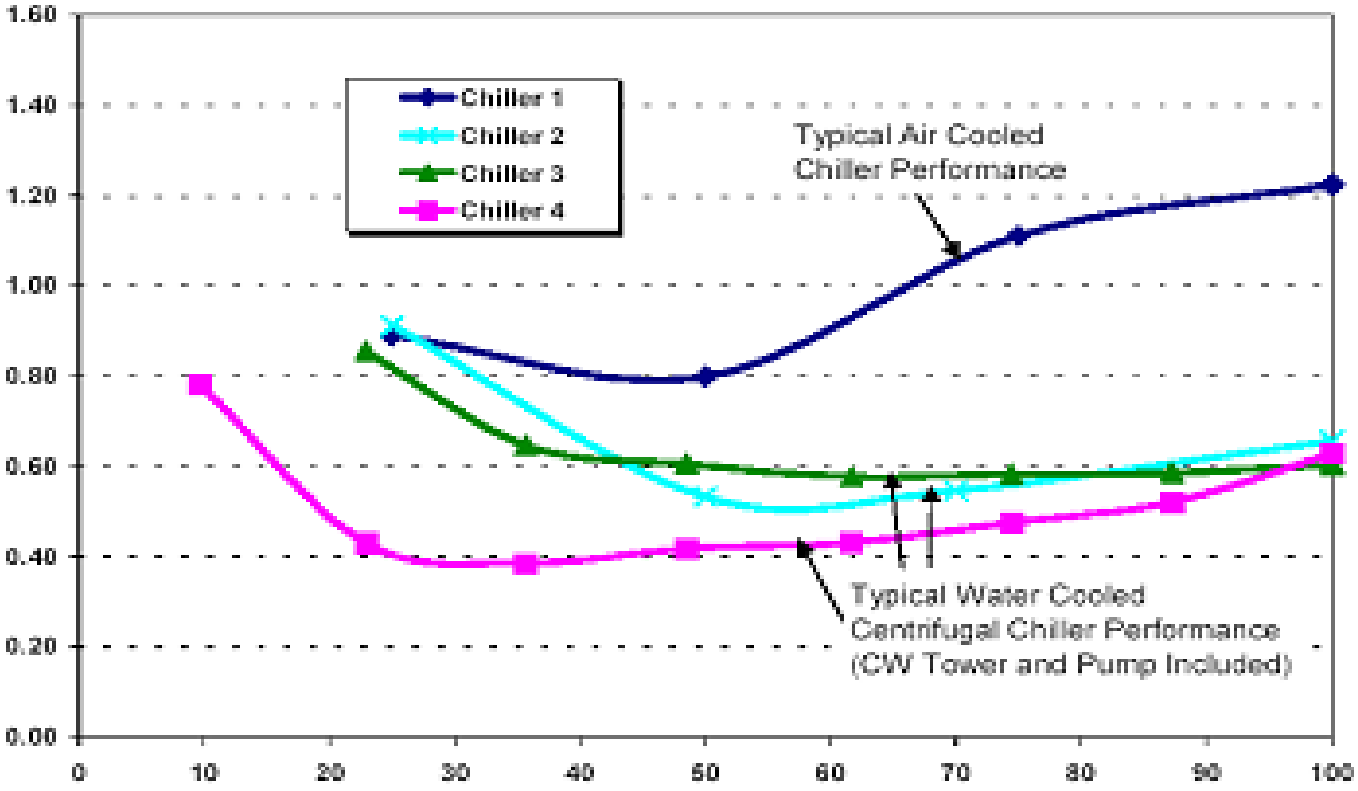
Current Energy Savings Strategies

- Heat recovery options (3 to 5 year payback)
- Free cooling (20% reduction in cooling energy)
- Commissioning (15% savings)
- Thermal storage (5%)
- Right-sizing to central plant to match phased load (10% reduction in cooling energy)

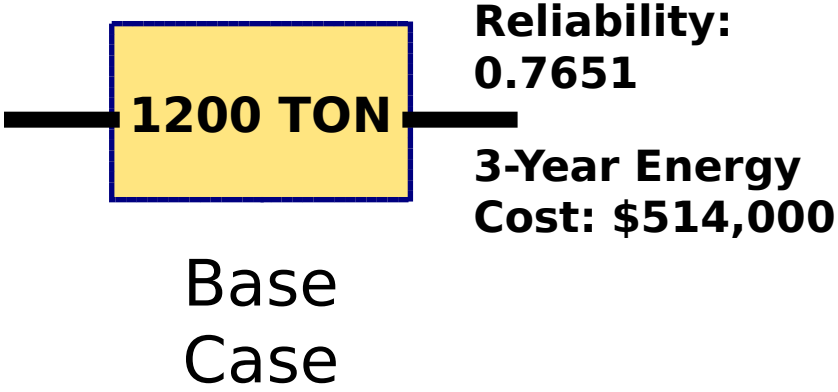
Central Plant



Part load performance of central plant equipment is important

Reliability and Availability

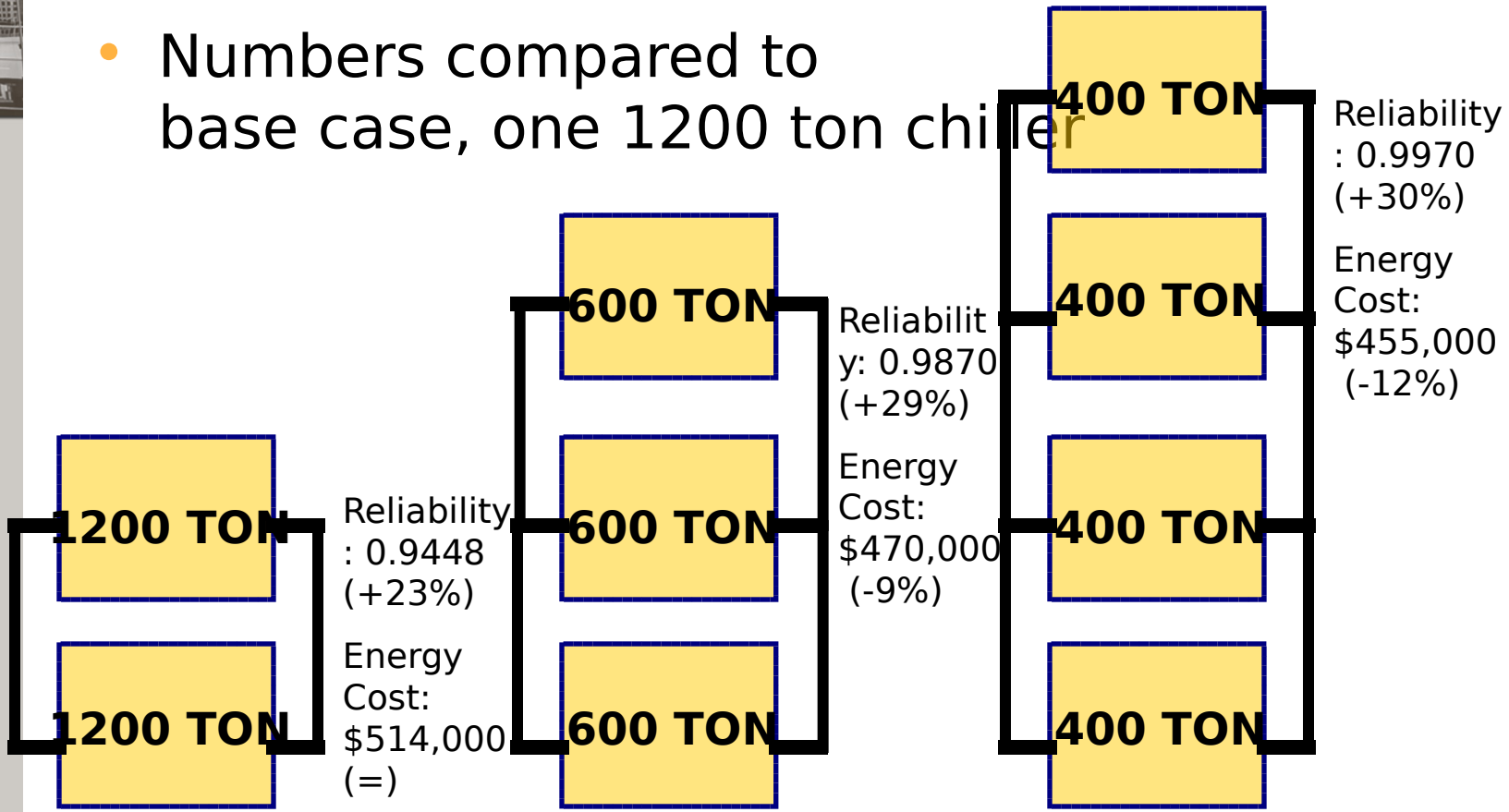
- Consider a 3 year phased move-in
  - Year 1: 30 W/SF (400 tons)
  - Year 2: 60 W/SF (800 tons)
  - Year 3: 100 W/SF (1200 tons)



- Require N+1 redundancy in chiller plant
- Three alternatives for providing N+1

Reliability and Availability

- Numbers compared to base case, one 1200 ton chiller

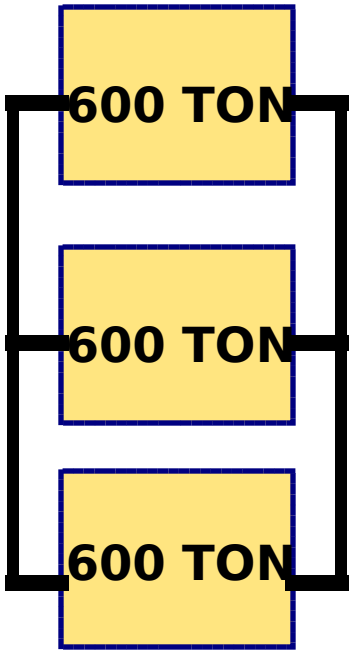


Thermal Storage

- Minimizes electrical use for on-peak cooling
- Store energy (make ice) during off-peak periods
- Off-peak periods have lower demand charges
- Redundant chillers can be run off-peak for thermal storage, so no additional chillers are needed

Thermal Storage

- 1200 ton cooling load, plant designed for N+1



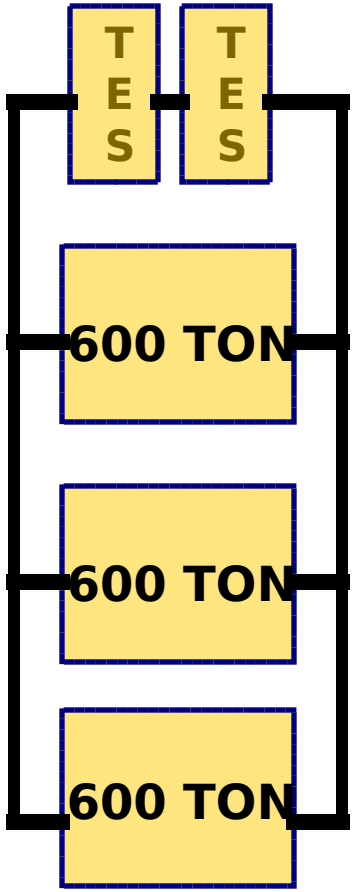
Maximum On-Peak Demand: 5630 kW

Total Annual Energy Cost: $1,990,100

Electricity Cost -$1,062,500

Demand Cost - $921,330

Base Case – 3 electric chillers



Maximum On-Peak Demand: 4926 kW (-13%)

Total Annual Energy Cost: $1,895,850 (-5%)

Electricity Cost - $1,080,650 (+2%)

Demand Cost - $808,900 (-13%)

Option 1 – 3 electric chillers, 1 w/TES

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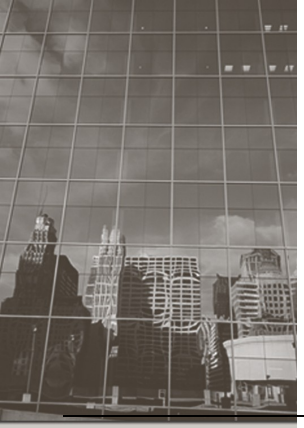

Commissioning by Project Phase

Program Phase	• Document Design Intent and Basis of Design
Design Phase	• Document Commissioning Plan
Construction Phase	• Factory Acceptance Testing-FAT • Start-up (Pre-functional) Testing
Acceptance Phase	• Site Acceptance (Functional) Testing • Integrated Testing
Post Acceptance Phase	• Review and Update Material • Train O & M Staff • Reliability Assurance Testing

Commissioning and Maintenance

- Improved reliability from initial startup of building
- Reduced first and on-going costs
- Training is required at startup and routinely throughout the life of the facility
- Maintenance effort directed at reliability centered maintenance and predictive maintenance, away from preventive maintenance

Closing Thoughts

- It is important to spend the time to conduct thorough analysis
- Building performance simulation is an accessible tool
- Utility rates and geography play an important role in overall energy costs
- Commissioning and maintenance improve reliability and energy efficiency
- A holistic process is the key to success

Thank You

- Questions?
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